Section 4
Guidance for Selection and Design of Permanent BMPs

This section presents design guidance for selection and design of permanent storm water quality controls (BMPs) in preparation of PS&E for any project.

4.1 Permanent Best Management Practices (BMPs)

The Caltrans Statewide SWMP listed permanent BMPs that Caltrans has evaluated and selected to manage sediment in storm water discharges from Caltrans facilities. The listing and working details for these BMPs are contained in Appendix B. Designers must consider these BMPs for applicability and incorporation into the PS&E during project design, and should not select BMPs other than those contained in the SWMP unless they have been evaluated and approved by the Storm Water Advisory Teams and Headquarters Environmental Program, and design details approved by Headquarters Project Development Program Managers.

4.2 General Design Practices for Permanent Soil Stabilization (Erosion Control)

The goal of an effective erosion control strategy is to maintain natural, pre-construction erosion rates to the maximum extent possible. In order to accomplish this goal on every project, designers should develop a strategy for permanently re-stabilizing all disturbed areas of the project by selecting appropriate BMPs for disturbed areas and drainage systems, that accomplish the following objectives:

(a) Preserve existing vegetation to the maximum extent possible.

(b) Minimize areas disturbed by the project

(c) Restabilize disturbed areas, according to Landscape Architecture and Maintenance recommendations, that are substantially complete for each phase and stage of construction.

(d) Control or minimize erosion potential of cuts, fills, and drainage patterns

The PS&E must be sufficiently detailed to prescribe construction requirements to implement the BMPs.

4.2.1 Soil Stabilization (Erosion Control) Strategies

If the need arises, to demonstrate that there will be no net sediment increase for post-development vs. pre-development conditions, use information on the soils, slopes, vegetation, and climatic conditions of the project site to estimate the difference in erosion and sedimentation with and without the project. This involves using a sediment-discharge relationship (e.g., the Universal Soil Loss Equation – USLE) to estimate differences in pre-construction and post-construction sediment yield; and selecting additional erosion control methods that minimize these differences. This process should be done in coordination with the District Landscape Architect, Geotechnical Engineer, Materials and the Storm Water Coordinator. Figure 4-1 presents a decision tree for developing an effective erosion source control design strategy and indicates BMPs to consider for various project conditions.

4.2.2 Protection of Slopes

Identifying potentially erosive slopes is the first step to ensure their protection. Site investigation of existing slopes on the project or in the immediate vicinity should be made, including existing facilities with similar combinations of slope, soil, vegetation and rainfall characteristics, to observe signs of erosion and effective erosion controls. Rill and gully erosion are the most obvious signs of erosive slopes. Rill and gully erosion occurs where sheet flow becomes concentrated in small, defined channels. Rills are typically a few centimeters deep and gullies are much larger. Also, review the project soils report to determine the maximum steepness for slope stability, considering both the surface erosion properties of the soils, as well as the structural integrity of the slope.

Impacts on existing slopes should be avoided or minimized to the maximum extent practical. The following general strategies for minimizing erosion of slopes should be used:

- Disturb existing slopes or create new slopes only if necessary
- Establish a vegetative cover on the slope(s) or provide other materials to control erosion due to rainfall
- Minimize the slope steepness/length
- Prevent runoff from concentrating, and/or collect concentrated runoff in stabilized channels/drains.

Avoiding Existing Slopes: The first goal in project design should be to minimize disturbance of existing slopes to the maximum extent practical, particularly where the existing slopes have a well-established vegetative cover. However, in some cases it may be desirable to remove existing vegetation if the result is a flatter, more stable slope. If the preliminary geometric design of the project would potentially impact existing slopes (i.e., requiring regrading and/or clearing), determine if the alignment and/or the geometric cross-section can be changed, or if retaining walls should be constructed, to minimize the impact on existing slopes. In addition, grading easements should be considered in order to decrease slope angle and erosion potential. If impacts on existing slopes cannot be avoided, then the project must include selection and design of permanent soil stabilization BMPs for slope protection of both disturbed existing slopes and newly created slopes. Staging can also be used to minimize the impact on existing slopes.

Minimizing Erosion on Slopes: The procedures and limitations for selection and design of soil stabilization BMPs for slope protection generally depend on soil type and slope steepness and length, and are described as follows:

(1) ***Slopes 1:4 (V:H) or flatter*** - Project design staff can select and design appropriate BMPs from the BMPs described below based upon guidance in this Guide and the working details in Appendix B.

(2) ***1:4 < Slopes < 1:2 (V:H)*** - A slope-specific soil stabilization design based upon appropriate BMPs from the BMPs described below must be prepared or approved by the District Landscape Architect and Storm Water Coordinator.

(3) ***Slopes 1:2 (V:H) or steeper -*** Such slopes have the highest potential for erosion. A site-specific slope stabilization design must be prepared or approved by the District Landscape Architect. In addition, written concurrence with the design must be obtained from District Maintenance Division and Storm Water Coordinator.

The BMPs described below must be considered for minimizing erosion on slopes; general guidance on each BMP is given. More detailed guidance can be found under each individual BMP described in Appendix B.

Slope Roughening/terracing/rounding

- Reduce slope steepness and length sufficiently to prevent runoff from concentrating and causing rill/gully erosion on long, steep slopes.

- All slopes should be rounded, with no sharp breaks, as shown in Standard Plan A62A.

- Terraces or benches should be considered to keep uninterrupted slope heights less than 9.1 m (30 ft) since the highest amount of erosion occurs at the upstream end of a rill or gully. Some erosion control manuals recommend maximum uninterrupted slope heights of 4.6 m (15 ft) if soils are very erosive.

- Runoff from terraces and steps should flow into diversion ditches installed where the terrace meets the slope. These diversion ditches should have a cross slope of at least 2%.

- Mid-slope diversions should be lined on fill slopes.

- Flatter slopes and terraces establish vegetation more readily, absorb rainfall impact, promote infiltration, and reduce runoff.

- Slope surfaces should be left rough to improve seed germination and plant growth.

- Design of slopes should be in conformance with Topic 304 of the Highway Design Manual.

Permanent seeding and planting

- All disturbed areas shall be planted or stabilized. If work on a slope is substantially complete, the slope should be stabilized with permanent controls.

- Slopes flatter than 1:4 (V:H) and less than 4.6 m (15 ft) high should be designed to be stabilized, to prevent formation of rills and gullies.

- Vegetation in combination with other forms of stabilization should be used on slopes steeper than 1:4 (V:H) and longer than 4.6 m (15 ft), in addition to using slope roughening/terracing/rounding; ditches, berm, dikes and swales; and overside drains.

- Grasses and mulches are the most effective and quickest treatment for initial erosion control. Trees and shrubs alone are not effective for initial erosion control and should be supplemented with appropriate vegetation, mulches, or blankets.

- The first 12 inches of topsoil (duff) shall be stockpiled and replaced prior to placing permanent controls.

Ditches, Berms, Dikes and Swales

- Top, toe and mid-slope diversion ditches, berms, dikes and swales, should be used to intercept runoff and direct it away from critical slopes without allowing it to reach the roadway. Typically, mid-slope diversion ditches should have a cross slope of at least 2%, and should be concrete or rock lined.

- Top of slope diversions should be paved along cut slopes where the slope length above the cut is greater than 12.2 m (40 ft).

- Earthen diversion ditches, berms, dikes and swales channelize flow and should be stabilized with vegetation or other materials to prevent erosion.

- Alternatively, drop structures can be placed along the diversion to maintain a grade sufficiently mild to prevent erosive velocities, or a paved chute can be placed down the side of the fill before the accumulated runoff in the diversion is sufficient to cause erosive velocities.

Overside Drains

- Overside drains are usually pipes or lined swales that convey runoff from the top of slopes to a stable channel/drain at the base of the slope.

- Size overside drains to convey large, infrequent storms down or around the slope (see Index 834.4 of the Highway Design Manual for more information on overside drains.)

- Overside drains in landscaped areas should be concealed by burial or other means.

- Design top and toe of slope diversion ditches/berms/dikes/swales to direct flow into the drain.

- Provide for outlet protection/velocity dissipation devices at the outlet of the drain, where needed.

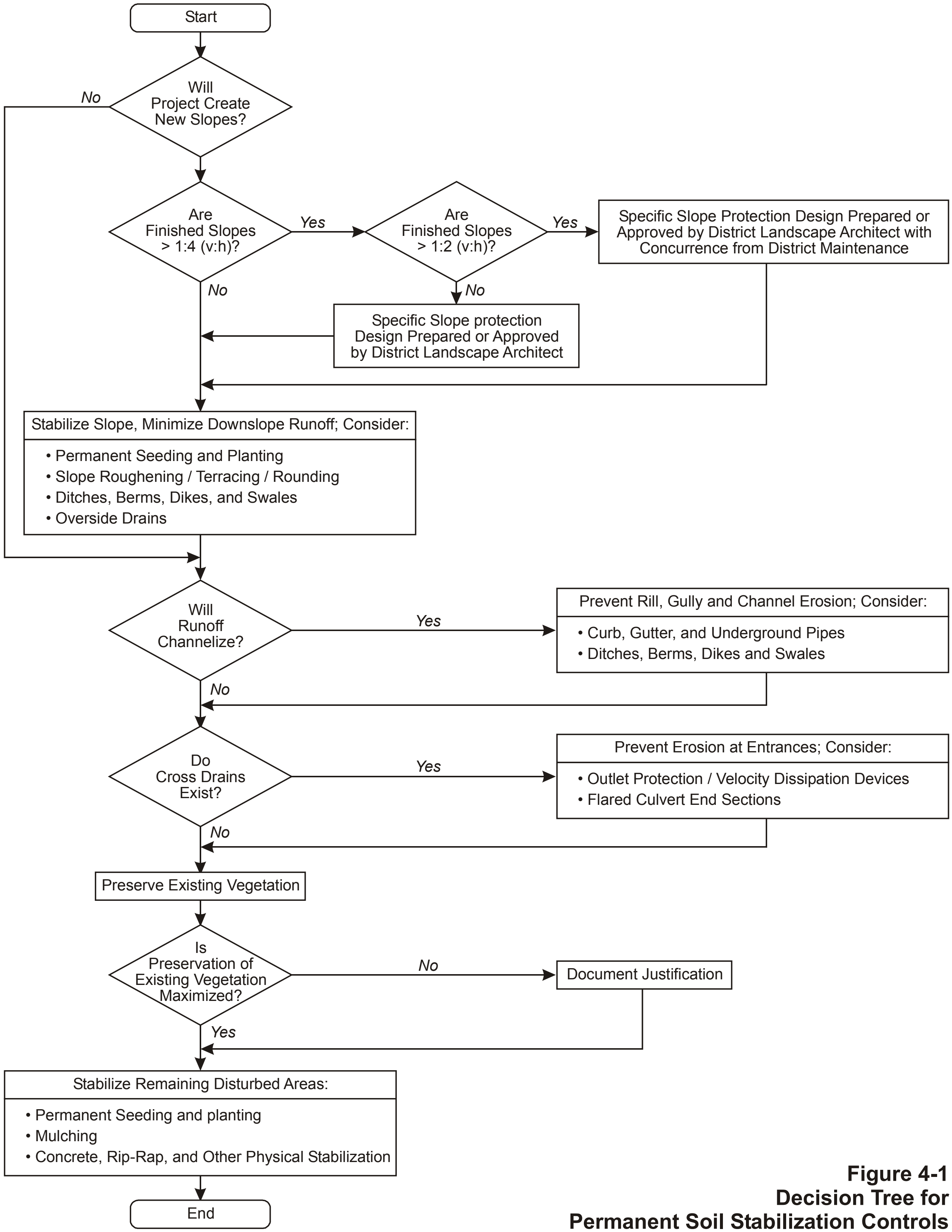

Figure 4-1
Decision Tree for
Permanent Soil Stabilization Controls

4.3 General Design Practices for Streambank Erosion Control

The project design must be developed to limit the potential for increased downstream streambank erosion to the maximum extent practical as a result of future discharges from the project. The major hydrologic changes which may affect channel stability as a result of changes in the highway drainage system relate to:

- The rate and volume of runoff, due to changes in the land surface,
- The sediment load from upstream, due to changes in land surface erosion and upstream channel aggradation or degradation,
- Hydraulic changes due to stream encroachments or crossings (constructions or expansion), or due to changes in the alignment of the channel itself.

Significant Storm Events

Frequent storm events have a large effect on small stream channel stability. When considering storm water management for channel stability, events with return periods on the order of 2 years can be significant.

4.3.1 Opportunities for Streambank Erosion Control

In principle, the designer may have control over any of the factors governing sediment transport capacity, but is commonly constrained by site limitations. These limitations may include factors such as grade restrictions imposed by the topography of the site, the nature of the native soils and streambed materials, and hydraulic structures that constrict or force bends in the channel. As a result, controls intended to limit erosion must be placed in a way that is sensitive to the specific conditions encountered in the particular site. Additional detailed information and procedures for design of erosion control for channel and shore protection is found in Chapters 860 and 870 of the Highway Design Manual.

Hydraulic Control

Hydraulic design for channels within the project site which are materially modified from their natural state must incorporate appropriate consideration of flow velocities and bed materials. After evaluating the peak rates of flow, design the channel section and bed materials so that the flow velocities generated by runoff events will not be sufficient to cause damage to the channel. Achieving this objective of long-term channel stability may require changes in channel shape, so that the channel section area is adequate, or may require channel lining, so that the channel itself is resistant to erosion.

Erosion and Sediment Control

Consider permanent soils stabilization practices set forth in Section 4.2 to reduce sediment loads in runoff from adjacent sites, and from the project, to pre-project levels both during and after construction; and to ensure that the chance of significant deposition and blockage in the downstream channel is minimized.

Hydrologic Control

The criterion applied to hydrologic control which is targeted at long-term channel stability is as follows:

(1) Evaluate velocity to ensure no net erosive impact. Runoff generated by the 2-year return period storm, calculated for conditions where antecedent moisture conditions are of average dryness, shall be controlled by design of the drainage system and storm water BMPs so that the peak flow rate for each event after a project is complete does not exceed the peak flow rate generated by the same event prior to the project.

(2) To achieve this objective may require the incorporation of a detention or infiltration (retention) basin to reduce the peak flow rate. Retention provides the added benefit of reduction in total volume of flow, but it will not be possible to incorporate retention (infiltration) in many cases, due to physical site constraints, so the minimum criterion is, as stated in (1) above, related to peak flow rates.

4.4 General Design Practices for Soil Stabilization for Concentrated (Channelized) Flows

Sheet flow runoff will concentrate when flow rates, velocities, and depths are large enough for the flow regime to become turbulent. The point where flow becomes turbulent and begins to channelize is difficult to predict, but rarely exceeds a flow path length of 61 m (200 ft) and occurs in much shorter lengths on steeper, smoother and less porous surfaces. The following BMPs should be considered to prevent erosion when concentrated flow is expected:

- Ditches, Berms Dikes and Swales
- Outlet Protection/Velocity Dissipation Devices

Additional detailed procedures for design of erosion control for channel and shore protection is found in Chapter 870 of the Highway Design Manual.

4.5 Preservation of Existing Vegetation and Restabilizing Remaining Disturbed Areas

Once special conditions of erosion of slopes, channels, and cross drains are addressed, the design must address stabilization of the remainder of the site by evaluating areas of the site other than slopes and maximizing the preservation of existing vegetation. Once the design has been established, and the area of actual construction known, the limits of the construction site must be established to provide some area for contractor operations, storage, etc. The construction site limits can be restricted to minimize additional construction period disturbance of existing vegetation, particularly on areas of the site that would present the greatest challenge to restabilization (e.g. problematic soil conditions), and sites where floodplains, wetlands, streambanks or perennial receiving waters with critical resources are on or adjacent to the site and would receive runoff directly from the disturbed areas. Areas that will not be disturbed must be clearly marked on the plans and access limitations should be shown on the plans and described in the Special Provisions. If preservation of existing vegetation cannot be maximized, the designer must document the justification for disturbing greater areas of the project site.

Items to consider when preserving existing vegetation and re-stabilizing the remainder of the project site include:

- Preserve existing vegetation to provide erosion and sediment control.
- The decision to save existing vegetation should include, at a minimum, the following considerations: age and life expectancy, health, aesthetic value, and wildlife benefits of vegetation.
- Vegetation to be preserved should be shown on the plans.
- Soil stabilization (permanent) is required on all disturbed areas.
- The use of native plants is appropriate for the project except for highly erosive slopes and channels, where denser, deep-rooted species may be required to compensate for the higher, more erosive flow velocities in these areas.
- Mulches and other forms of physical stabilization (e.g., rock, rip-rap, geotextile materials) should be considered for portions of the site where vegetation cannot be easily established or where it would require permanent irrigation, increase highway maintenance costs, and/or interfere with highway operations.
- Stabilizers with rough surfaces and/or pores that store runoff and promote infiltration are preferable to paved or other smooth liners that tend to increase runoff and potentially pass erosion problems downstream.

4.6 General Design Practices for Permanent Treatment Control BMPs (Tahoe Basin or Similar Conditions, or Other Special Circumstances)

Where permanent treatment control BMPs are required, they should be used in combination with soil stabilization BMPs because soil stabilization practices are generally much less expensive to construct and maintain than treatment controls. Furthermore, if the sediment loads resulting from erosion within the right-of-way are excessive, these facilities will tend to fill more rapidly and may subsequently fail to serve their intended purpose and treatment is a more effective method. At the present time, there are only three treatment control BMPs that Caltrans has conditionally approved for use on a project-by-project basis; they are: infiltration basins, detention basins and traction sand trap devices.

Special Circumstances for Considering Infiltration and Detention Basins

As stated in Section 2.3, Caltrans considers treatment control devices (infiltration and detention basins) for water quality control, only if all of the following special circumstances are met:

- Runoff from the completed facility will discharge to significant areas of highly valuable habitat in which Federal or State listed aquatic resources have been identified, or will discharge to a storm drain that drains directly to such habitat, and;
- Caltrans runoff constitutes a substantial portion (more than 10%) of the total flow to such habitat.

Tahoe Basin or Similar Conditions

Traction sand trap devices are only considered for roadways in the following locations where sand is applied for traction control:

- The Lake Tahoe and Truckee River hydrologic units in District 3
- Elevations above 7,000 ft in the Mammoth Creek Hydrologic Unit in District 9
- The Carson River East Fork and West Fork hydrologic units in District 10

4.6.1 Selecting the Appropriate Treatment Controls

When the need for detention or infiltration basins has been identified during the environmental review process as described in Section 2.3, and it has been determined which BMP is suitable for application at this site, the designer must then examine the facility with respect to fitting it into the right-of-way including convenient access for maintenance, and the cost to construct and maintain the facility.

Unless the control has been previously identified, and right-of-way reserved for this purpose, the feasibility of including such control measures at the detailed PS&E stage is limited to what can be incorporated within the right-of-way defined during development of the final geometric base maps. One possible exception would be when an opportunity is identified for developing an off-site joint-use drainage and/or water quality control feature as part of a cooperative agreement with a local jurisdiction. This would require project-specific negotiations and coordinated design efforts. If the need to consider an infiltration basin is first determined during the detailed PS&E stage, the financial feasibility must also be assessed. Selection and design of treatment controls must be performed in coordination with the Hydraulics Unit.

4.6.2 Integrating Treatment Controls with Other Facilities

In many instances, and especially in areas where available right-of-way is limited, treatment control BMPs can be integrated into common project features such as medians, shoulders, setbacks, within interchange areas, landscaped areas, parking areas and unused right-of-ways. Treatment control BMPs may be considered for open areas within interchange areas and alongside the road, but safety considerations and access for maintenance must be fully considered when selecting the location.

In some cases, drainage, flood control and storm water pollution controls can be integrated into a single facility that achieves all objectives cost-effectively. The design guidelines laid out in the individual BMPs contained in Appendix B must be carefully followed to ensure that the large storms used to size the drainage and flood control portion of these sediment basins do not "flush out" the pollutants already captured by the facility. Alternatively, the large storms may bypass around the water quality control facility.

Design facilities for siting storm water quality controls consistent with normal Caltrans design and maintenance practices. Final layout and design of treatment controls must be coordinated with the Hydraulics Unit, the District Landscape Architect and the Storm Water Coordinator.

4.6.3 Detention Strategies

Combination drainage, flood control and storm water pollution control basins must provide separate storage volumes and outlet controls for each objective, each sized as if they were separate basins and then "stacked" in a manner that meets all objectives as noted below:

- The objective of storm water detention for flood control, sometimes referred to as "peak shaving", is to reduce the peak rate of runoff from relatively intense, infrequent design storms (e.g., a 10-year storm or larger). Generally, the runoff from smaller storms passes through these basins without significantly altering the discharge hydrograph or removing pollutants.

- Storm water treatment controls employ a different storage strategy; they capture and detain almost all runoff from a water quality design storm much smaller than typical flood control design storms

4.6.4 Incorporating Maintenance Access

Treatment control BMPs must be periodically maintained in order to be effective. Maintenance must be consulted to determine maintenance access requirements. These requirements must then be incorporated into the design.